# The Application of Routing Planning on the Fieldwork Investigation

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**ABSTARCT**

Geographic Information System (GIS) integrates different types of digital geographic information. To maximize the information sharing and reduce the unnecessary duplication, the government departments should collect data and set up the data standard, quality requirement and updating system. Take “Institute of Transportation Traffic Road Network Digital Atlas” for example, the establishment and updating references include topographic base maps, aerial photography, satellite images and GPS vehicle tracking maps etc. Beside the spatial data as described above, the attribute data (ex. one way, turning restriction, speed limit, etc) usually is acquired through different management agencies or the fieldwork investigation which is most time and labor consuming.

The fieldwork investigation has been widely applied now, but most applications are not considering routing planning systematically. The efficiencies of the fieldwork investigation could be enhanced if we could find a minimum cost route for collecting data, subject to the specific nodes or links in network. This problem can be regarded as an extension of the Traveling Salesman Problem (TSP) and Chinese Postman Problem (CPP). In this study we propose modeling and heuristics solution for the fieldwork investigation. Numerical problems and real applications in “Institute of Transportation Traffic Road Network Digital Atlas” are provided for demonstration as well.

## 1. INTRODUCITON

The Road Network Digital Atlas data can be directly accessed via government departments or be generated by aerial photography; however, as to data-collecting, there are still situations that we cannot fully control such as low returning rate and low complement of research data, or problems flowing out when being checked. In order to overcome these situations, the fieldwork investigation is applied in this study for higher standard of research validity. The fieldwork investigation can be classified into two categories: (1) Differential Global Positioning System (DGPS) can collect the spatial data fast but the attribution data hardly. (2) The fieldwork investigation collects the attribute data (ex. one way, turning restriction, speed

limit, traffic lane, road shoulder, road name, etc).

The fieldwork investigation has been widely applied now, but most applications are not considering routing planning systematically. The efficiencies of the fieldwork investigation could be enhanced if we could find a minimum cost routing for collecting data, subject to the specific nodes or links in network. This problem can be regarded as an extension of the Traveling Salesman Problem (TSP) and Chinese Postman Problem (CPP). In this study we propose model to the above problem via set up an artificial arc and node to convert ARP into NRP. In order to simplify the complexity, we assume that:

1. Network:

(1) Cluster problem is not considered in this research; hence, we assume that every district would be has professional investigation troop.

(2) The specific nodes or links in network are known.

2. Cost:

(1) Cost estimation is based on the total travel time spent on investigation.

3. Investigation troop:

(1) The number of vehicles is given.

This study is divided into several sections. After this introductory section and the literature review in Section 2, a model is formulated and discussed in Section 3. In Section 4 we propose a heuristic algorithm. In Section 5, we demonstrate our model based on test problems. At the end of Section 5, we test our model on an actual case in Taipei—"Institute of Transportation Traffic Road Network Digital Atlas".

## 2. LITERETURE REVIEW

The literature reviews on Road Network Digital Atlas and the fieldwork investigation are examined, followed by the reviews on routing problems. However, there are little researches on mixed problems of TSP and CPP are too scarce to be discussed. Therefore, we put more emphasis on the conversion from Arc Routing Problems (ARP) to Node Routing Problems (NRP).

### 2.1 Road Network Digital Atlas and the fieldwork investigation

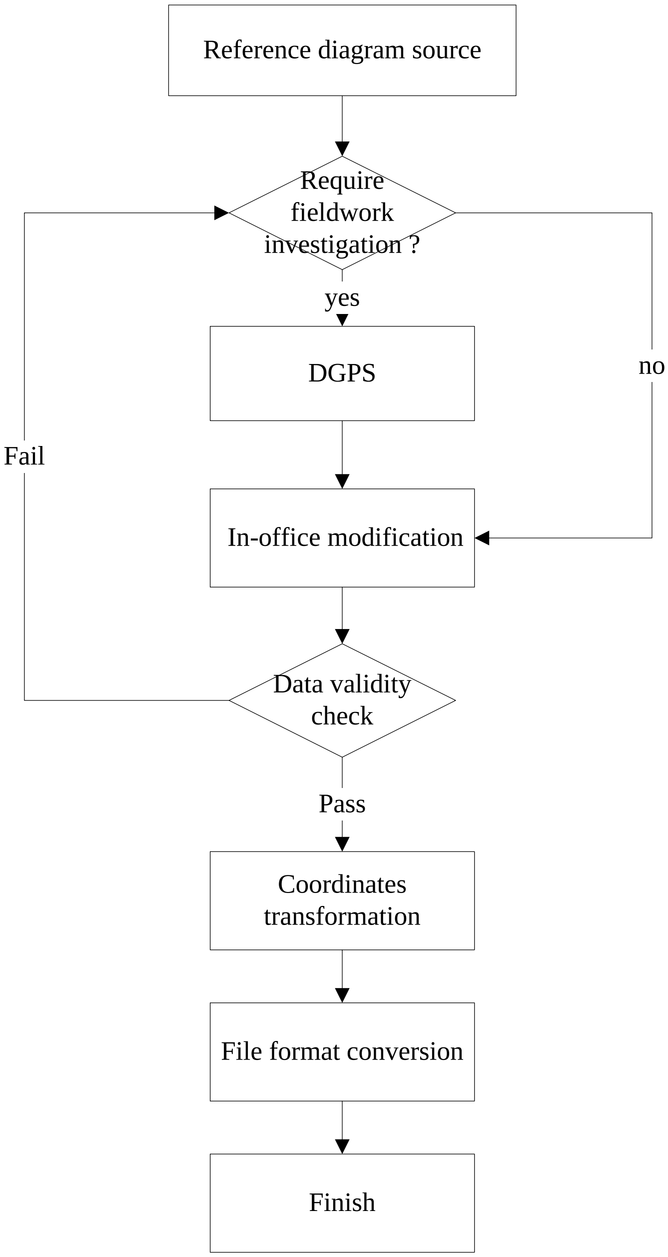


Figure 1. Road Network Digital Atlas creation/updating flow chart [1]

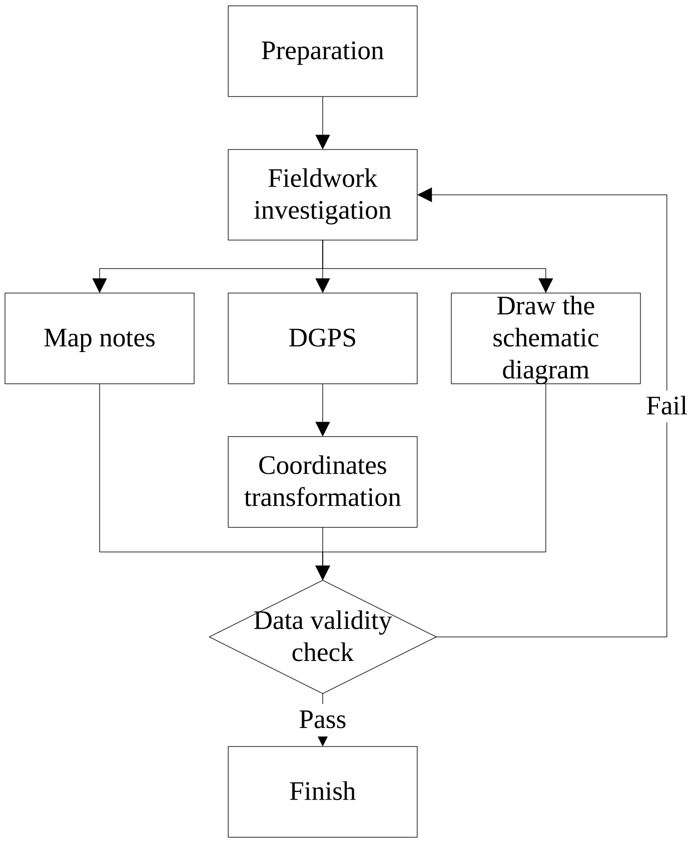


Figure 2. The fieldwork investigation flow chart [1]

Figure 1 indicates the flow chart of generating Road Network Digital Atlas. In this diagram, reference resources are checked the fieldwork investigation is required. Through out the whole process, data validity check would be preceded till it pass and later the validated data would be converted into the right data format and filed. Figure 2 shows more details of the fieldwork investigation process. However, route planning had not been took in these studies.

Arc routing related information can be obtained with ease via aerial photography and DGPS. Nevertheless, a number of streets and roads are still remained unknown due to the difficulties of obtaining the right attribute data. In order to solve this problem, the fieldwork investigation application is required.

2.2Routing problems

Practically many routing problems require a certain route to visit the specific nodes in certain network, which can be broadly defined as Node Routing Problem (NRP) and Arc Routing Problem (ARP). These problems are pretty common in daily lives. The most well-known routing problems are Traveling Salesman Problem (TSP) and Chinese Postman Problem (CPP).

The TSP is a problem in combinatorial optimization studied in operations research

and theoretical computer science. Given a list of cities and their pairwise distances, the task is to find a shortest possible tour that visits each city exactly once.

The CPP is a problem to determine a minimum length walk covering each segment at least once. The CPP can be categorized into three types based on the direction of arcs in the network: (1) Undirected Chinese Postman Problem (UCPP). (2) Directed Chinese Postman Problem (DCPP). (3) Mixed Chinese Postman Problem (MCPP).

A generic ARP that subsumes a number if well-known routing problem is the Capacitated Arc Routing Problem (CARP). This problem, introduced by Golden and Wang, may be briefly defined as follows: Given a network where costs and demands are associated with each arc, find a set of minimum cost vehicle cycles, based at a distinguished node call the depot, and traversing all arcs of positive demand, so that the total demand serviced by each cycle does not exceed the vehicle capacity $W$ .As pointed out by Golden and Wong, a number of well-known node routing problems can be viewed as special cases of the CARP simply by splitting any original node into two nodes joined by an arc, and assigning the demand of the original node to the arc.

The CARP can be formulated as a standard vehicle (node) routing problem by Pearn et al.(1987)[5]. They transform ARP into NRP by three new nodes, shown as Figure. 3. and the directivity is $s_{ij} => m_{ij} => s_{ji}$ or $s_{ji} => m_{ij} => s_{ij}$ .Aminu and Eglese(2006)[8] was inspired by Pearn et al.(1987) and modified the concept. They transform ARP into NRP by two new nodes, shown as Figure. 4., the directivity and time windows are considerate. In their study, Total cost and the sequence of route can be obtained but part of the distance matrix between the new nodes (calculated with shortest path) is inaccuracy ( Sz-Chi Chen, 2007)[3].

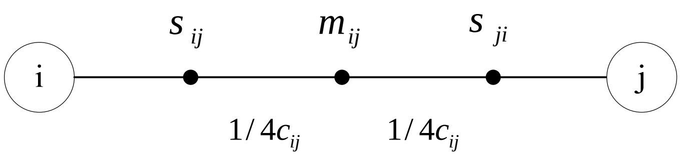


Figure 3. Transforming CPP to NRP [5]

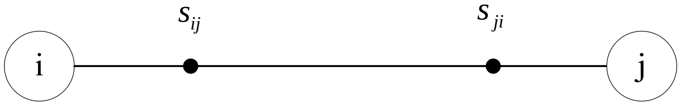


Figure 4. Modification of Pearn et al.'s approach [8]

DCPP is P (polynomial) problem (Edmonds and Johnson, 1973[9]) and can be obtained the solution quickly by minimum cost flow, Lin and Zhao algorithm. But there are situations of multiple solutions and we can make sure the sequence of the route.

## 3. MODEL FORMULATION

The fieldwork investigation can be regarded as an extension of TSP and CPP. Literature reviews on these kinds of problems were often proposed as artificial nodes, which converts ARP into NRP. In this study, we try to set up artificial arcs and nodes to convert the problem visiting certain nodes and arcs of a network, and we hope through this research, we can conclude that the mixed problems are equal to TSP.

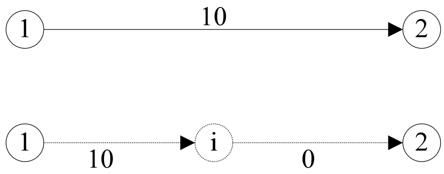


Figure 5. Transforming CPP to TSP

As shown in Figure 5, the artificial arc and node can replace the original arc, and the cost between the node 1 and the node $i$ is the original arc cost 10; the cost between the node $i$ and the node 2 is cost 0. Hence, the mixed problem can be regarded as an extension of the TSP that we can and can be formulated as a mixed integer problem, as follows:

$$\min_{\{x_{ijk}\}\in\Omega} Z(\tau) = \sum_i \sum_j \sum_k \{c_{ij}x_{ijk} + c_{0j}x_{0jk}\} \quad (1)$$

Flow conservation constraints:

$$\sum_j \sum_k x_{ijk} = 1 \qquad \forall i \in N, k \in K \quad (2)$$

$$\sum_i \sum_k x_{ijk} = 1 \qquad \forall j \in N, k \in K \quad (3)$$

$$\sum_i x_{ihk} - \sum_j x_{hjk} = 0 \qquad \forall h \in N, k \in K \quad (4)$$

$$x_{0ik}, x_{ijk} \in \{0,1\} \qquad \forall i, j \in N, k \in K \quad (5)$$

Definitional constraints:

$$a_j = d_i + c_{ij} \quad if \quad x_{ijk} = 1 \qquad \forall i, j \in N, k \in K \quad (6)$$

$$a_j = c_{0j} \quad if \quad x_{0jk} = 1 \qquad \forall j \in N, k \in K \quad (7)$$

$$\sum_i \sum_j \{c_{ij}x_{ijk} + c_{0j}x_{0jk} + s_i x_{ijk}\} \le work\ time \quad \forall k \in K \quad (8)$$

The objective of this model, as shown in Eq. (1), Eq. (2)~(4) are flow conservation constraints: Eq. (2) requires that only one vehicle $k$ can leave from node $i$ once. $k$ is belong to Investigation troop. Eq. (3) denotes that only one vehicle can arrive at node $j$ once. Eq. (4) states that for each node h, the entering vehicle must eventually leave this node. Eq. (5)

designates $x_{ijk}$ as a 0–1 integer variable. $x_{ijk}$ equals 1 if vehicle $k$ departs node $i$ toward node $j$. Otherwise, $x_{ijk}$ equals 0. Eq. (6) and (7) define the arrival time at node j. Eq. (8) denotes that every vehicle has working-time limit.

The departure time at each node is treated as a decision variable with which there is no need to impose numerous sub-tour constraints. In ordinary cases, there are situations of multiple solutions, as shown in Figure 6. Nodes and arcs to be investigated are shown as dotted and replaced by the artificial ones. The distance between artificial nodes should be the shortest path cost. Take Figure 6 for instance. There is more than one solution: (1)0→1→2→3→4→5→0. (2) 0→1→3→2→4→5→0. (3) 0→1→4→5→3→2→0. (4) Etc. With no other constraints or time windows, there are often multiple solutions to the problems. This study sets the investigation time $s_i$ as a constant and the arrival time as a variable. Thus, the algorithm can come up with one answer, such as (1) 0→1→2→3→4→5→0, and in practice artificial node 2 would only be calculated once at the first time, which means the investigation would only be held once- first pass and pass by at the second time .

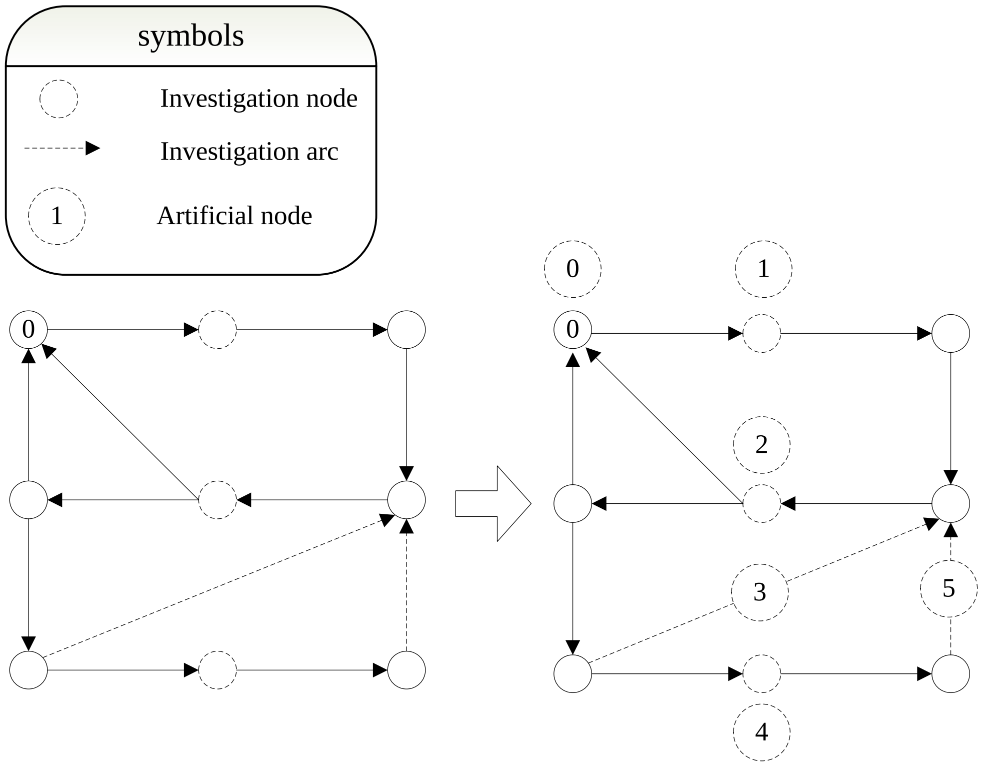


Figure 6. Network example

## 4. SOLUTION ALGORITHM

We divide the algorithm into two phases. Phase I is deal with mixed problems of TSP and CPP. In phase I We transform CPP to TSP and Compute shortest path cost of every artificial nodes and generate input data. Phase II is to solve TSP. In phase II the insertion method is used for route construction, while the Or-opt node exchange algorithm is adopted for route improvement. Then the algorithm can come up with one answer of Phase II, and we convert

the result into an original route.

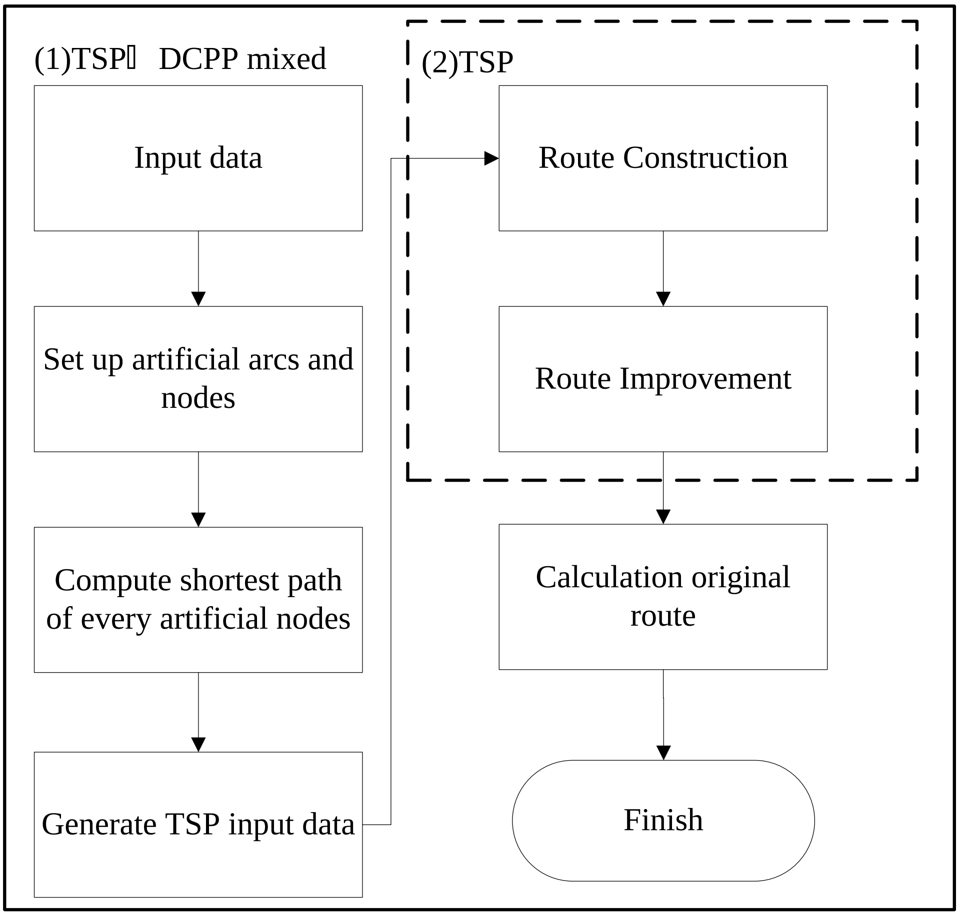


Figure 7. Unified framework of solution procedure

## 5. NUMERICAL EXAMPLES

### 5.1 Examination of Numerical examples

In order to demonstrate the conversion from ARP to NRP in this study, we compare results that are base on Lin and Zhao algorithm, our algorithm, and LINGO9.0. The criterions are the total travel time and number of arcs in the five examples. To begin with Case (1), the result is shown below as Figure 8: (Node 1 is depot).

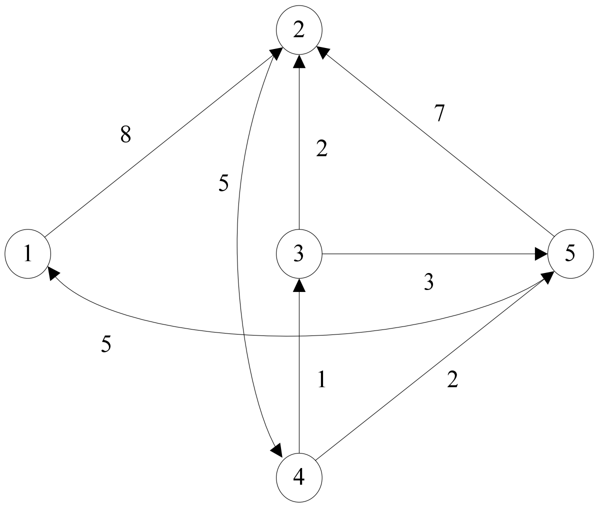


Figure 8. Case(1) network

a. Lin and Zhao

Code is based on Lin and Zhao's algorithm.

Routes:

(1) 1→2→4→3→5→2→4→3→2→4→5→1.

(2) 1→2→4→5→2→4→3→2→4→3→5→1.

(3) 1→2→4→3→2→4→3→5→2→4→5→1.

**Table 1**.Case (1) Lin and Zhao result

| Arc | Cost r(i,j) | Number of Arcs h(i,j) | w(i,j) |
|---|---|---|---|
| 1,2 | 14 | 1 | 14 |
| 2,4 | 0 | 3 | 0 |
| 3,2 | 8 | 1 | 8 |
| 3,5 | 4 | 1 | 4 |
| 4,3 | 0 | 2 | 0 |
| 4,5 | 2 | 1 | 2 |
| 5,1 | 4 | 1 | 4 |
| 5,2 | 12 | 1 | 12 |
| Total cost | 44 | | |
| Total number of arcs | | 11 | |

b. Our algorithm

The algorithm of has fully demonstrated in the previous section. First, we transform ARP into NRP. Then we set no investigation time ($s_i = 0$) for comparison with Lin and Zhao algorithm, LINGO9.0. The result is shown below as Table 2 and we convert the result into an original route.

**Table 2**.Case (1) algorithm input

| artificial node | forward node | toward node | investigation time $s_i$ |
|---|---|---|---|
| 1 | 1 | 2 | 0 |
| 2 | 2 | 4 | 0 |
| 3 | 3 | 2 | 0 |
| 4 | 3 | 5 | 0 |
| 5 | 4 | 3 | 0 |
| 6 | 4 | 5 | 0 |
| 7 | 5 | 1 | 0 |
| 8 | 5 | 2 | 0 |

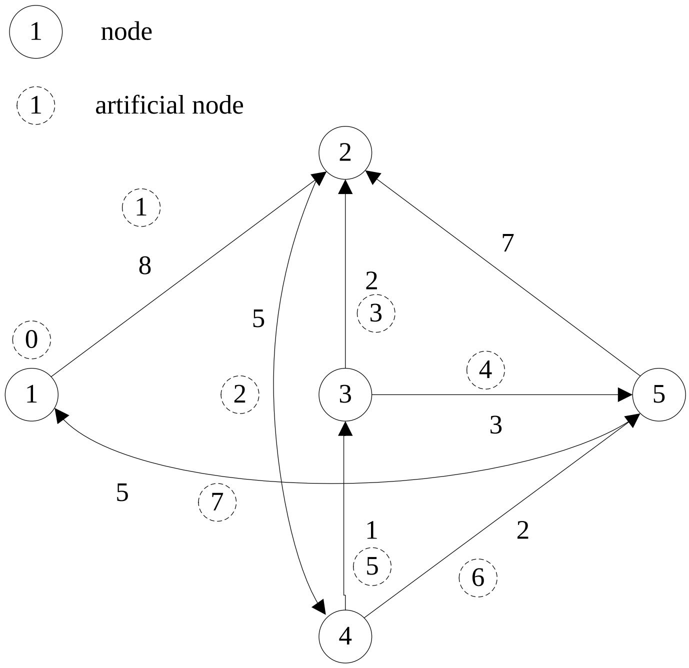


Figure 9. Case(1) artificial network

**Table 3.**Case (1) algorithm result

| artificial node | arrival time $a_i$ | departure time $d_i$ | cost $c_{ij}$ | investigation time $s_i$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 8 | 0 |
| 1 | 8 | 8 | 9 | 0 |
| 4 | 17 | 17 | 7 | 0 |
| 8 | 24 | 24 | 6 | 0 |
| 5 | 30 | 30 | 2 | 0 |
| 3 | 32 | 32 | 5 | 0 |
| 2 | 37 | 37 | 2 | 0 |
| 6 | 39 | 39 | 5 | 0 |
| 7 | 44 | 44 | 0 | 0 |
| 0 | 44 | 44 | 0 | 0 |

Total time：44 min.

Total number of arcs：11.

Artificial node route：0→1→4→8→5→3→2→6→7→0(0 denotes depot.)

Original route：1→2→4→3→5→2→4→3→2→4→5→1(1 denotes depot.)

LINGO9.0

Total time：44 min.

Total number of arcs：11.

(Global Optimum)

**Table 4**.Case (1) LINGO9.0 result

| Variable | Value | Reduced Cost |
|---|---|---|
| X( 1, 2) | 1 | 8 |
| X( 1, 2) | 3 | 5 |
| X( 1, 2) | 1 | 2 |
| X( 1, 2) | 1 | 3 |
| X( 1, 2) | 2 | 1 |
| X( 1, 2) | 1 | 2 |
| X( 1, 2) | 1 | 5 |
| X( 1, 2) | 1 | 7 |

**Table 5**.Result comparisons

| Case | Lin and Zhao | | Our algorithm | | LINGO9.0 | |
|---|---|---|---|---|---|---|
| | Objective value | Total number of arcs | Objective value | Total number of arcs | Objective value | Total number of arcs |
| (1) | 44 | 11 | 44 | 11 | 44 | 11 |
| (2) | 73 | 14 | 73 | 14 | 73 | 14 |
| (3) | 45 | 12 | 45 | 12 | 45 | 12 |
| (4) | 88 | 15 | 88 | 15 | 88 | 15 |
| (5) | 29 | 8 | 29 | 8 | 29 | 8 |

In view of several different numerical examples, algorithm can be applied in the small scale example very well. After transforming the result into original route, we can get total cost, the number of arcs, and arrival time of each artificial node that we can know the sequence.

## 5.2 Examination on Road Network Digital Atlas

For testing modeling and algorithm in large-scale network, Taipei city network, from Road Network Digital Atlas, produced by Institute of Transportation (IOT) is chosen to be the basis of this examination, shown as Figure 10 and 11, which aims to investigate the major road flows in Taipei. The assumptions are as followed:

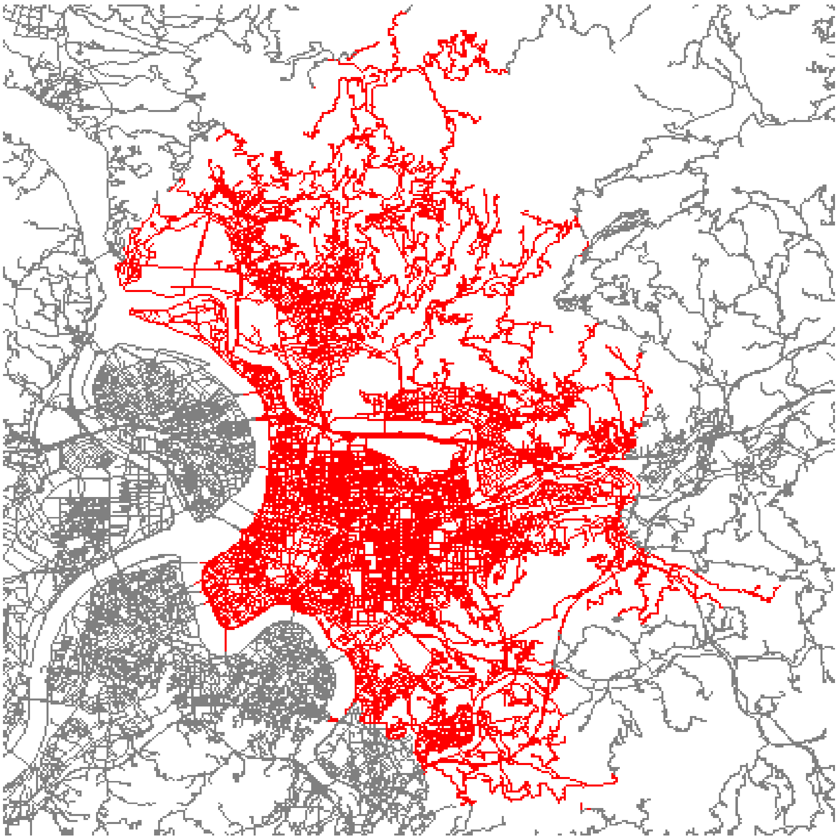

Figure 10. Network of Taipei city

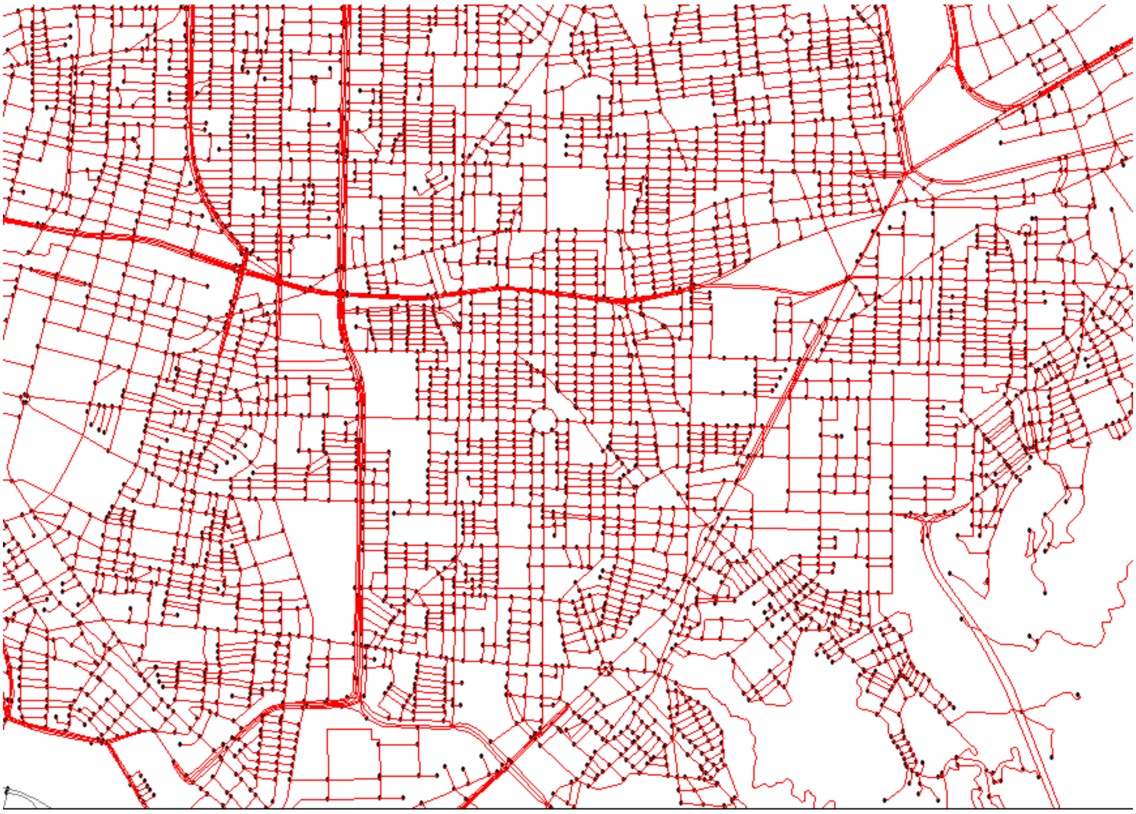

Figure 11. Street network of Taipei city

(1) Single depot, which generates 275 nodes and arcs to be investigated; the investigation time is assumed to be 1 minute.

(2) The investigation work troops are 10 vehicles at the maximum and each of them is under work hour constraints. However, in reality every vehicle takes quite a plenty of time to complete the whole investigation, and practically speaking, usually one vehicle is distributed to every working troop. Therefore, we might take the number of working days into consideration. Based on the working-time limit given, 10 vehicles should be able to work for 10 days as defined.

(3) Working-time limit are set as following: 2 hours, 4 hours, 6 hours, 8 hours and unlimited.

From Table 6 and Figure 12, we can know that working-time limit should be set when having large-scale network investigation; otherwise unreasonable working time, such as case (6), might occur. Meanwhile, total travel time does not change a lot under different work-hour limit; on the other hand, the number of vehicles used changes dramatically. If the fieldwork investigation range is larger, more vehicles are required. We could use several vehicles or use many working days with a vehicle to complete the fieldwork investigation. Case 2, 3 (work time limit: 3hours, 4hours) are more reasonable than others. And the route result of case 3 is shown

in Appendix.

**Table 6.**Cases Comparison

| Case | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Working-time limit(min) | 120 | 180 | 240 | 360 | 480 | unlimited |
| Total number of vehicles | 6 | 4 | 3 | 2 | 2 | 1 |
| Total(min) | 427.66 | 426.81 | 426.32 | 418.01 | 418.58 | 405.48 |

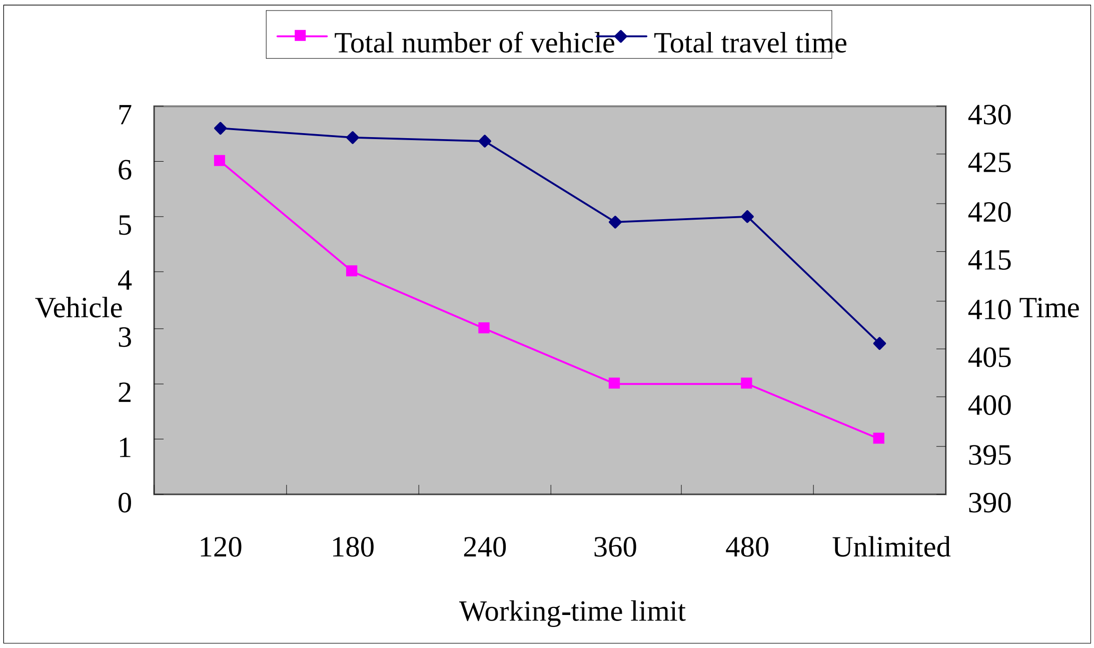


Figure12. Cases comparison

## 6. CONCLUSION

The value of Road Network Digital Atlas is sustained the maintenance and update of the data. Therefore, obtaining the up-to-date data is vital. Also, the fieldwork investigation not only checks for problems but also update and expand data via data collection. We can reduce the labor consumption by routing planning systematically.

The conclusion of this study can be summarized as follows:

1. In this study, we try to set up artificial arcs and nodes to convert the problem visiting certain nodes and arcs of a network, and the fieldwork investigation can be regarded as an extension of TSP that we formulated as a mixed integer problem.
2. The traditional of TSP and CPP studies are lack of discussion on working-time limit. For practical applications, work time limit is considered in this study.
3. For testing modeling and algorithm, result comparisons of Lin and Zhao, LINGO9.0 are demonstrated. We also tested in large-scale network, Taipei city network, from "Institute of

Transportation Traffic Road Network Digital Atlas". We provided some routes for the fieldwork investigation.

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## APPENDIX

| Vehicle | Route |
|---|---|
| 1 | 0(0.0,0.0)--1(0.2,1.2)--3(1.4,2.4)--5(2.8,3.8)--29(4.1,5.1)--7(5.4,6.4)--28(6.6,7.6)--61(8.1,9.1)--72(9.3,10.3)--74(10.6,11.6)--78(12.2,13.2)--84(14.1,17.1)--86(17.4,18.4)--88(18.9,19.9)--90(20.1,21.1)--91(21.5,22.5)--93(22.7,23.7)--95(24.1,25.1)--103(26.6,27.6)--107(28.5,29.5)--109(29.7,30.7)--112(31.5,32.5)--115(33.0,34.0)--105(34.6,41.0)--94(41.8,42.8)--110(46.1,47.1)--82(48.6,49.6)--85(50.0,51.0)--92(51.3,52.3)--83(53.0,54.0)--97(54.3,55.3)--99(55.7,56.7)--100(57.1,58.1)--102(58.7,59.7)--96(60.1,61.1)--98(61.8,62.8)--79(63.7,64.7)--55(64.8,65.8)--56(66.2,67.2)--37(67.5,68.5)--57(68.8,69.8)--65(71.5,72.5)--67(72.8,73.8)--70(74.2,75.2)--73(75.5,76.5)--114(82.4,83.4)--242(85.5,86.5)--245(87.5,88.5)--253(89.5,90.5)--243(93.8,94.8)--236(95.5,96.5)--234(98.0,99.0)--232(99.3,100.3)--211(102.4,103.4)--207(104.1,105.1)--208(105.4,106.4)--210(107.5,108.5)--214(109.2,110.2)--230(111.1,112.1)--231(113.1,114.1)--235(114.5,115.5)--237(116.1,117.1)--240(118.6,119.6)--241(120.0,121.0)--87(121.4,122.4)--89(122.7,123.7)--81(124.9,125.9)--54(126.3,127.3)--75(128.4,129.4)--76(129.8,130.8)--77(131.1,132.1)--58(132.5,133.5)--66(135.0,136.0)--68(136.3,137.3)--20(141.3,142.3)--69(143.1,144.1)--71(144.4,145.4)--59(147.1,148.1)--35(151.7,152.7)--62(154.4,155.4)--26(157.3,158.3)--8(158.5,159.5)--9(159.7,160.7)--14(161.3,162.3)--16(162.7,163.7)--18(163.8,164.8)--11(166.5,167.5)--12(167.8,168.8)--15(169.3,170.3)--13(172.3,173.3)--25(174.0,175.0)--23(176.4,177.4)--22(178.6,179.6)--33(182.4,183.4)--63(185.5,186.5)--64(186.8,187.8)--19(188.2,189.2)--21(189.5,190.5)--36(192.3,193.3)--4(194.5, |

| | |
|---|---|
| | 195.5)--6(195.7,196.7)--10(197.1,198.1)--24(198.4,199.4)--27(199.7,200.7)--30(200.9,201.9)--31(202.3,203.3)--32(203.6,204.6)--34(205.1,206.1)--2(206.5,207.5)--44(207.8,208.8)--217(209.4,210.4)--47(211.2,212.2)--52(212.4,213.4)--53(213.6,214.6)--43(220.5,221.5)--49(222.4,223.4)--50(223.7,224.7)--39(229.8,230.8)--41(231.1,232.1)--45(232.4,233.4)--46(233.7,234.7)--48(235.0,236.0)--40(236.3,237.3)--42(237.6,238.6)--38(238.9,239.9)--0(239.9,0.0)-- total number of node : 124 |
| 2 | 0(0.0,0.0)--244(12.8,16.2)--249(18.6,19.6)--251(20.2,21.2)--252(22.3,23.3)--247(26.6,27.6)--233(29.3,30.3)--206(31.8,40.6)--196(41.4,42.4)--183(43.7,44.7)--225(47.0,48.0)--222(48.8,49.8)--223(50.2,51.2)--224(51.3,52.3)--17(53.3,54.3)--137(54.6,55.6)--136(56.0,57.0)--146(60.2,61.2)--148(61.5,62.5)--153(63.6,64.6)--157(64.9,65.9)--160(66.2,67.2)--149(70.4,71.4)--151(71.7,72.7)--155(73.0,74.0)--170(74.5,75.5)--166(76.8,77.8)--171(78.1,79.1)--172(79.8,80.8)--173(81.1,82.1)--175(83.7,84.7)--203(88.0,89.0)--116(96.0,97.0)--117(97.7,98.7)--118(99.1,100.1)--121(101.4,102.4)--262(103.0,104.0)--259(105.3,106.3)--261(107.2,108.2)--119(108.6,109.6)--120(110.3,111.3)--122(111.6,112.6)--124(112.9,113.9)--131(117.0,118.0)--133(118.3,119.3)--154(125.5,126.5)--152(130.1,131.1)--156(131.7,132.7)--158(133.1,134.1)--161(134.5,135.5)--162(135.8,136.8)--159(141.4,142.4)--163(143.6,144.6)--169(147.0,148.0)--164(149.3,150.3)--165(151.1,152.1)--167(152.5,153.5)--168(153.8,154.8)--150(155.7,156.7)--180(157.4,158.4)--200(163.3,164.3)--101(169.9,170.9)--128(171.4,172.4)--125(173.0,174.0)--127(174.7,175.7)--129(176.3,177.3)--130(178.0,179.0)--132(179.1,180.1)--134(180.5,181.5)--135(182.0,183.0)--138(183.5,184.5)--139(184.8,185.8)--140(186.4,187.4)--141(187.7,188.7)--142(189.2,190.2)--143(190.6,191.6)--144(191.9,192.9)--145(193.2,194.2)--147(195.0,196.0)--181(196.7,197.7)--182(198.3,199.3)--184(199.7,200.7)--185(201.6,202.6)--194(202.9,203.9)--195(204.4,205.4)--198(206.5,207.5)--201(208.4,209.4)--212(214.0,215.0)--197(216.1,217.1)--199(217.8,218.8)--204(219.2,220.2)--209(221.1,222.1)--215(222.4,223.4)--213(225.9,226.9)--227(227.9,228.9)--226(230.0,231.0)--228(231.6,232.6)--229(233.8,234.8)--238(236.8,237.8)--0(239.3,0.0)-- total number of node：98 |
| 3 | 0(0.0,0.0)--187(13.1,14.1)--216(18.6,19.6)--51(21.4,22.4)--80(25.2,26.2)--254(32.4,33.4)--275(39.4,40.4)--188(55.1,56.1)--190(56.9,57.9)--193(59.0,60.0)--239(63.9,64.9)--60(66.6,67.6)--106(71.5,72.5)--108(72.9,73.9)--104(74.6,75.6)--111(77.0,78.0)--113(78.5,79.5)--265(82.8,83.8)--270(87.1,88.1)--271(90.0,91.0)--273(93.1,94.1)--274(95.3,96.3)--264(98.4,99.4)--260(99.9,100.9)--266(101.6,102.6)--258(106.2,107.2)--268(108.1,109.1)--269(110.0,111.0)--255(112.1,113.1)--257(113.8,114.8)--267(116.5,117.5)--272(118.4,119.4)--256(125.7,126.7)--263(129.7,130.7)--123(131.9,132.9)--126(133.7,134.7)--174(146.3,147.3)--177(148.0,149.0)--178(149.2,150.2)--179(150.4,151.4)--218(165.9,166.9)--186(167.8,168.8)--191(169.9,170.9)--248(187.4,188.4)--250(188.8,189.8)--246(190.8,191.8)--189(210.6,211.6)--192(212.2,213.2)--202(215.6,216.6)--176(227.5,228.5)--219(229.6,230.6)--220(231.3,232.3)--221(232.8,233.8)--205(236.2,237.2)--0(239.7,0.0)--total number of node：53 |
| Working-time limit | 240 min |
| Total number of vehicle | 3 |
| Total time | 426.32 min |